

MTCA.4-based high-speed digitizer system for J-PARC MR

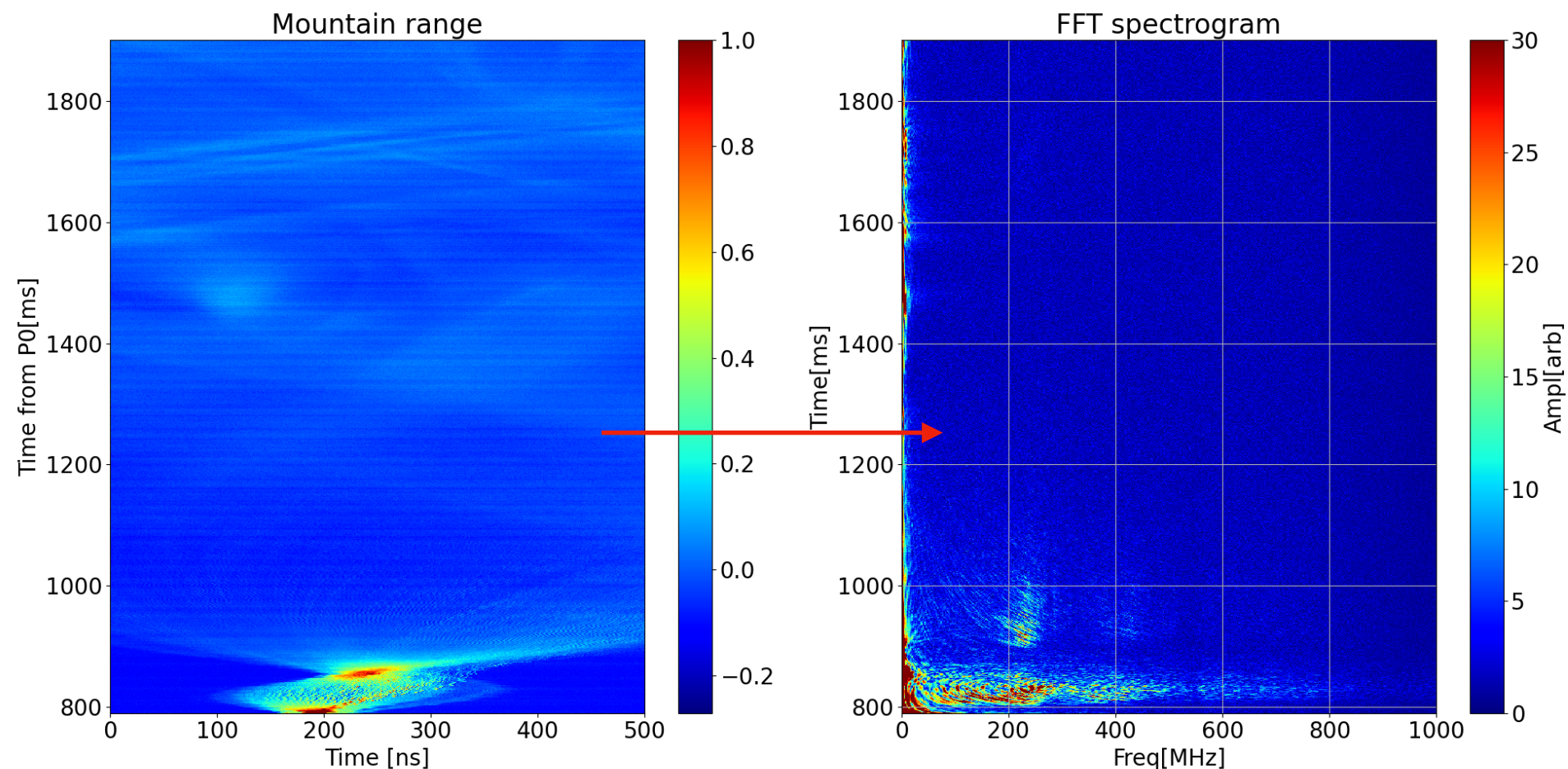
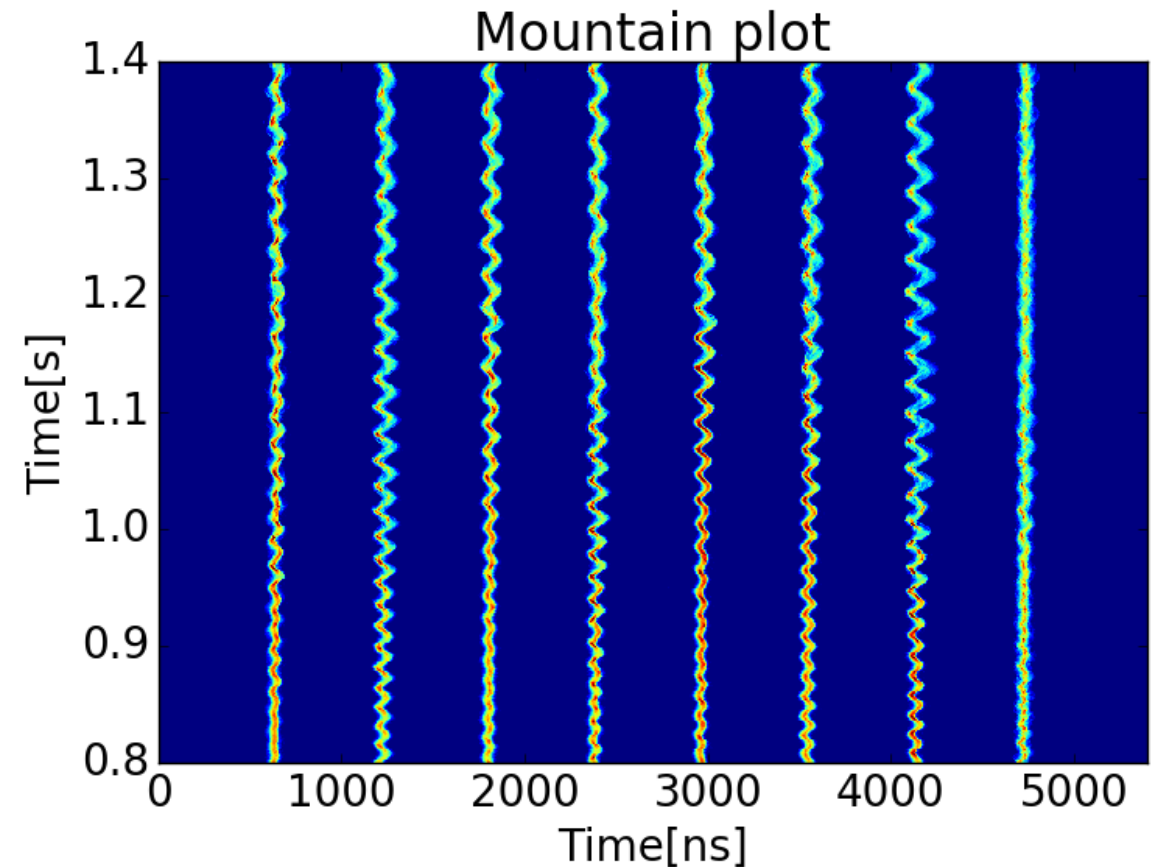
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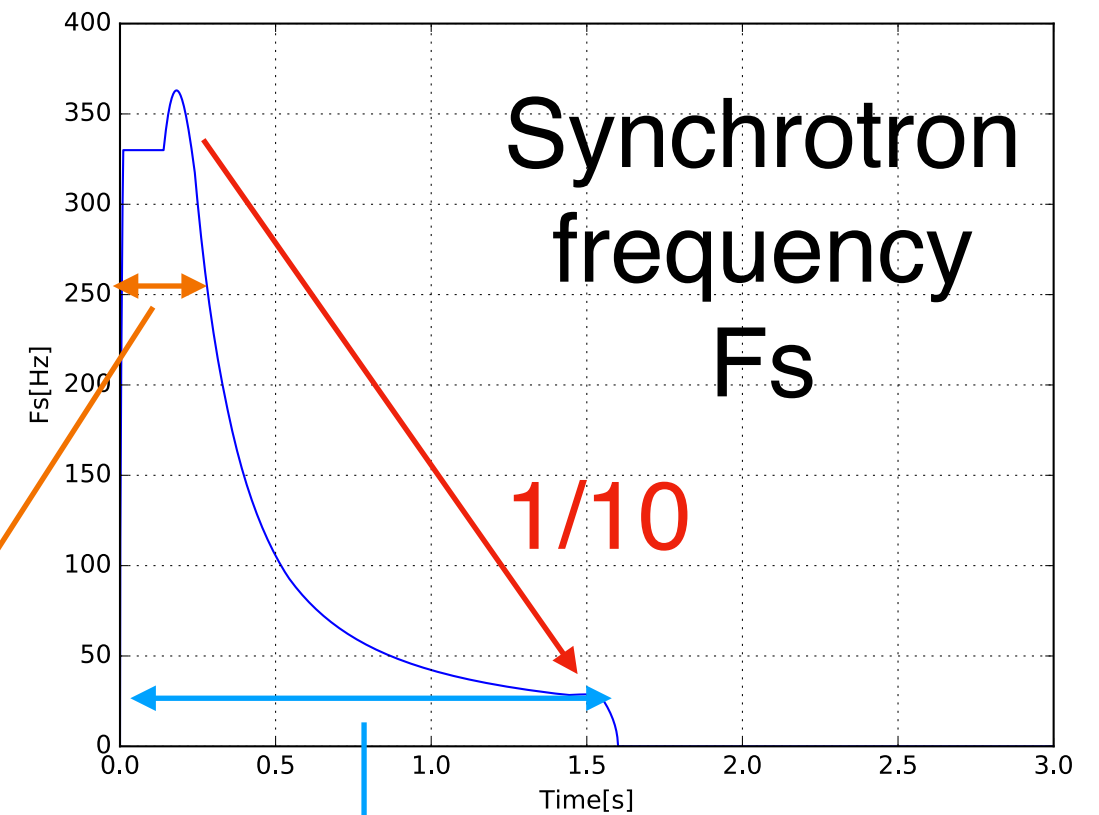
Importance of beam signal monitoring in the J-PARC MR

- The waveforms of the beam signals recorded by the oscilloscopes are essential for monitoring and analyzing the beam's longitudinal properties.
 - Motion of the beam bunches
 - Spectral Analysis by FFT

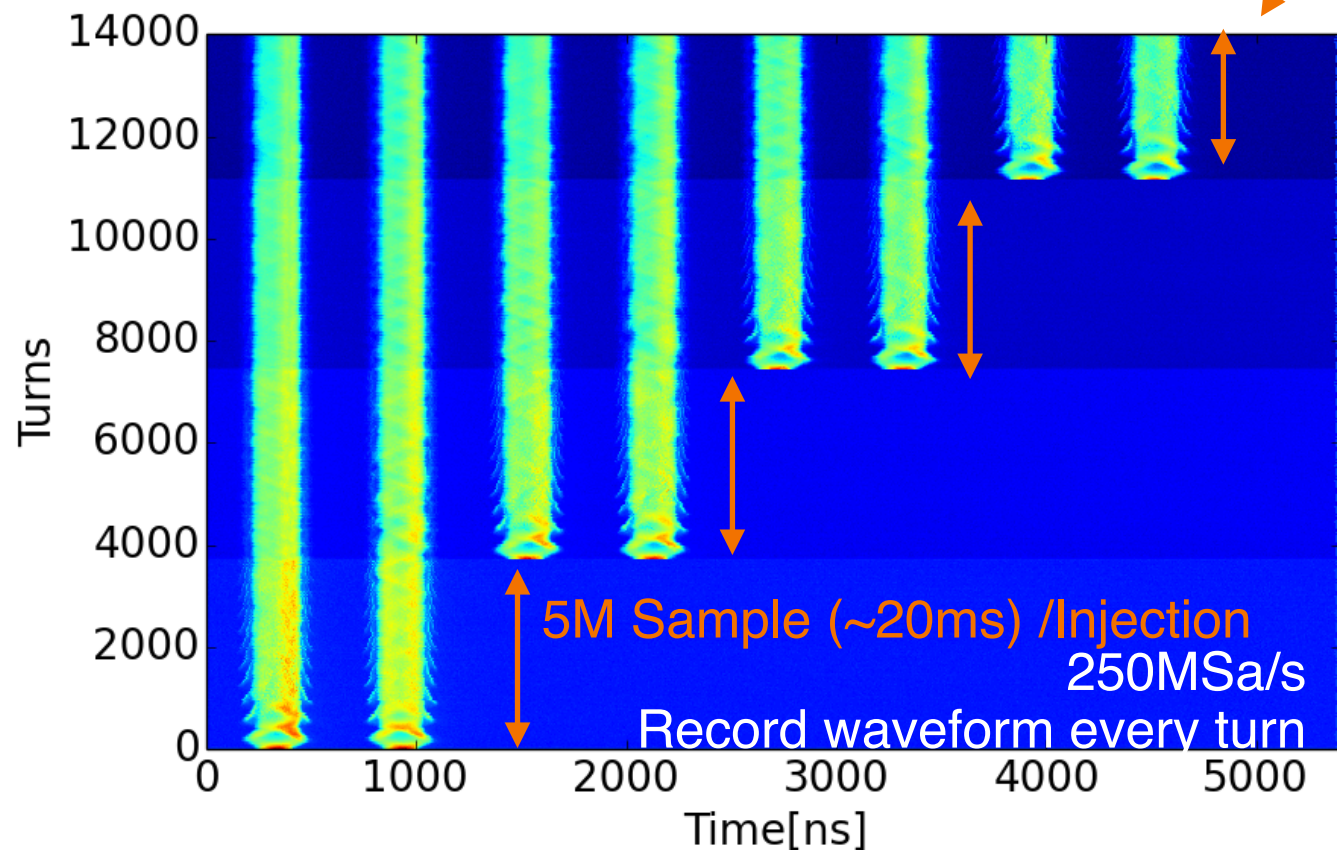


Current situation @J-PARC MR

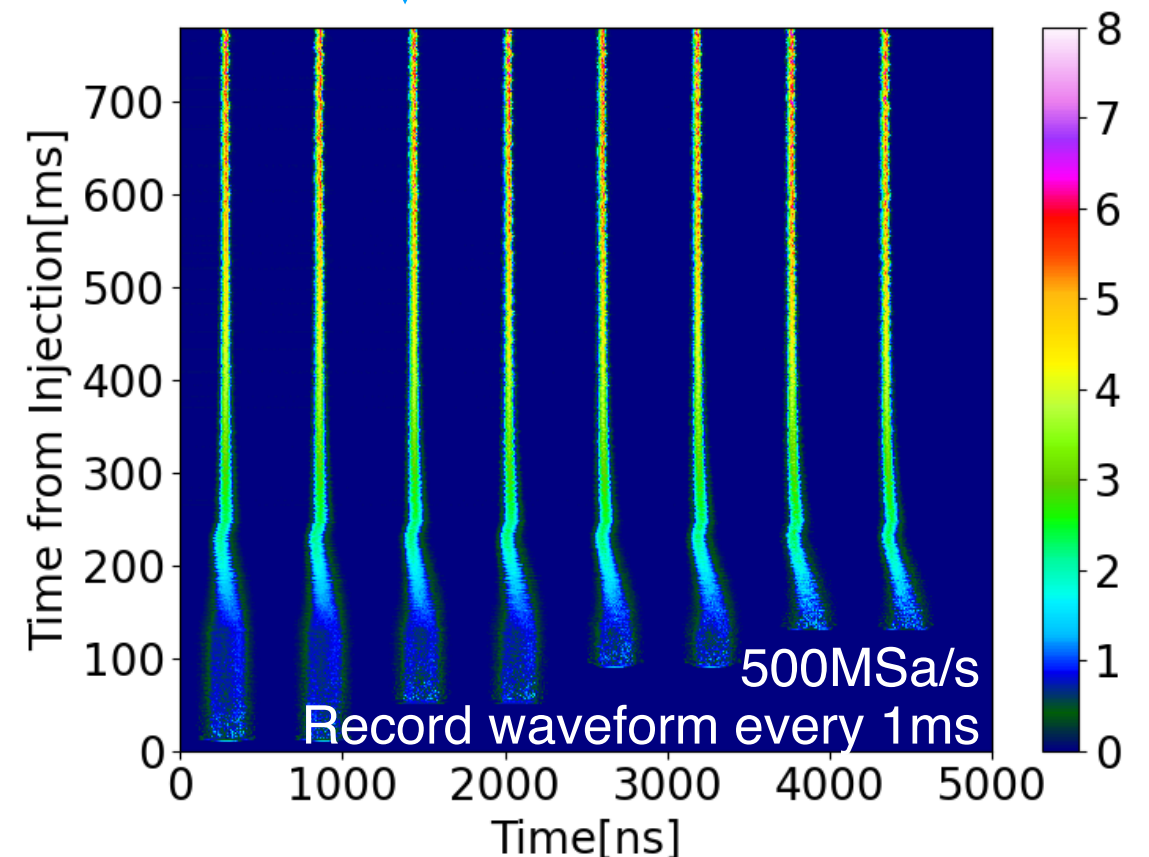
- Acceleration time of J-PARC MR: 0.8s.
- Memory on the oscilloscopes: 10~20M samples
 - Not long enough to store all waveforms for the whole acceleration period.
- Since the oscillation frequency changes significantly during acceleration, two oscilloscopes are used with different recording cycles and sampling speeds.
- Data readout via VXI11 protocol over ethernet.



Oscilloscope for monitoring Injection period



Oscilloscope for monitoring whole the acceleration



Requirement for new digitizer

- Required specs.
 - Sampling speed faster than 500MSa/s.
 - Analog bandwidth >500MHz for the spectral analysis.
 - Memory:1~2GByte to store the waveform for the whole acceleration period.
 - Readout interface faster than VXI11 via ethernet.
 - A compact and stand-alone system is preferred.
- **A high-speed MTCA digitizer AMC with a small MTCA chassis as a solution!**

MTCA.4-based high-speed digitizer system for J-PARC MR

- 1U MTCA chassis with high-speed digitizer AMC module.
- Digitizer: Teledyne SP Device ADQ14
 - 14bit, 1GSa/s, 700MHzBW, 4ch input, 2GB memory.
- Vadatech MTCA chassis VT816 (Ubuntu Linux)
 - Embedded MCH with CPU (Intel Xeon E3-1125)
 - Fast readout via PCIeexpress bus in the MTCA backplane.

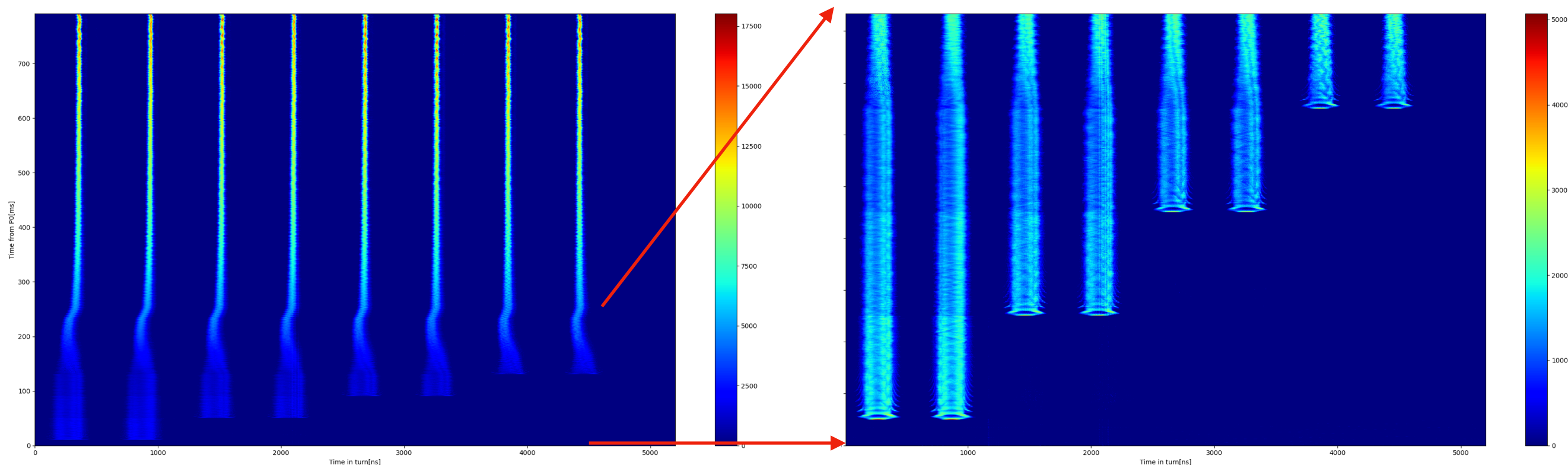


Trouble in the integration...

- We had some troubles during the integration of AMC and chassis.
 - Compatibility issue between AMC and chassis
 - Hot-swap switch could not change the status of ADQ14. (Stay off)
 - FRU information cannot be identified by MCH.
 - These features of ADQ14 worked correctly with the nVent small chassis.
 - It turned out that the FRU information stored in ADQ14's MMC device locator record did not fully comply with IPMI standards.
 - After the fix of firmware by Teledyne, ADQ14 worked successfully with VT816.
- Installation of the Xwindow system in the Linux OS on VT816.
 - At first, we tried to install them on the AlmaLinux, but the X window system did not work properly, probably due to the graphic driver compatibility (Silicon Motion 750 (SM750)).
 - Instead, we installed them on Ubuntu, and everything worked fine.

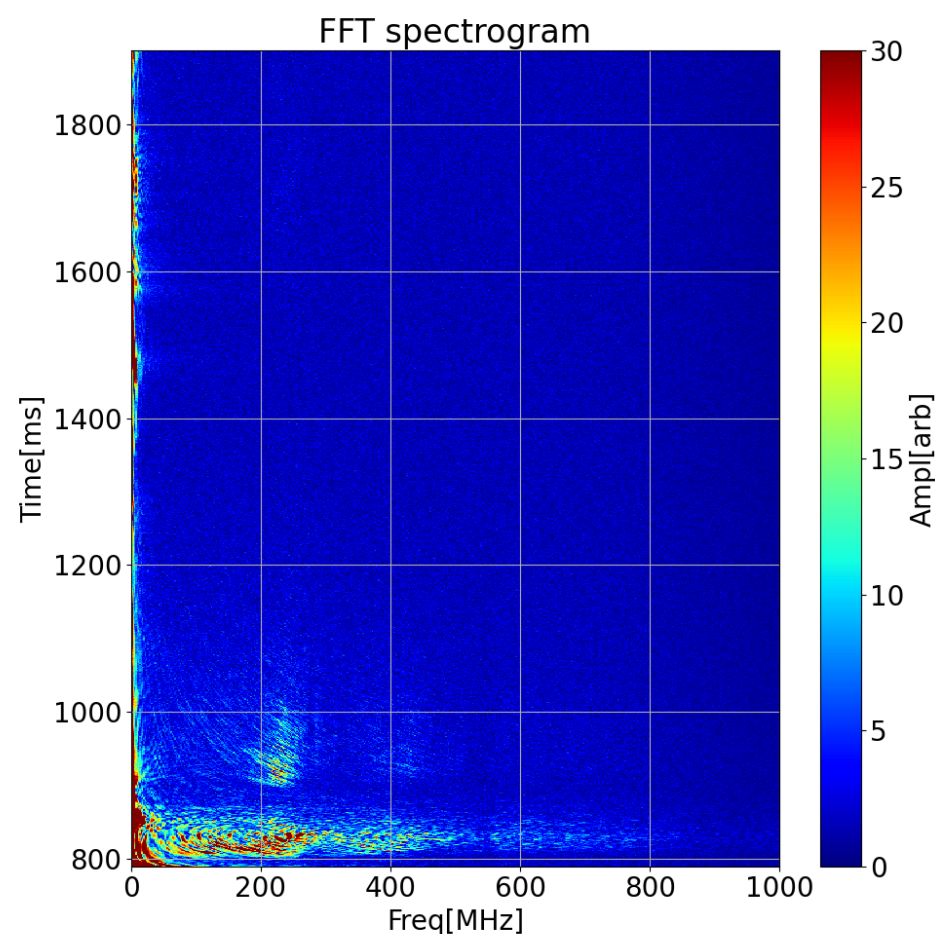
New digitizer in operation at J-PARC MR

- The new digitizer is installed in the J-PARC MR and has been operating since November 2024.
- Successfully recorded the waveform of beam signal for the whole accelerating period (790ms) with 1GSa/s.
- Just started the operation by recording single-shot data by the script.
 - Automatic data acquisition for continuous beam operation is under preparation.

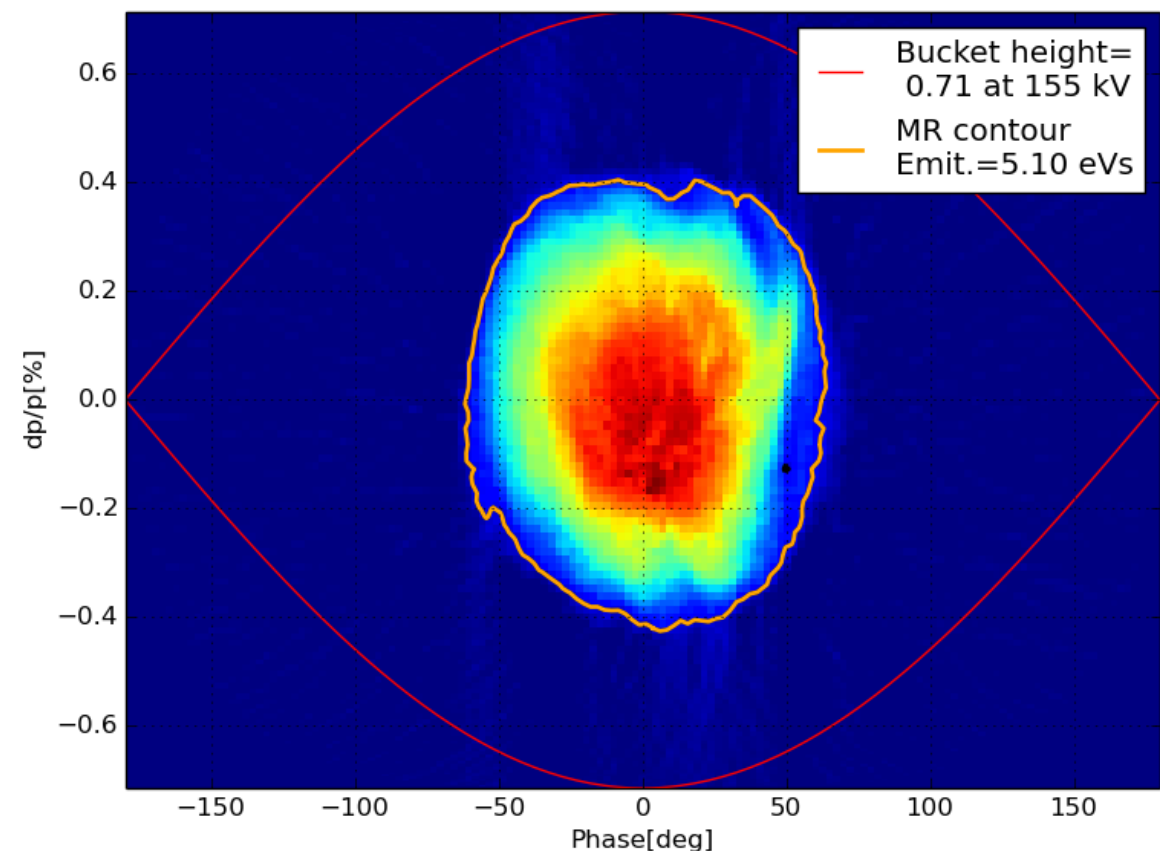


Future Prospect

- Automatic data acquisition via EPICS
- Peer to Peer data transfer to GPU
 - Online analysis such as FFT and Tomography reconstruction.
 - Machine Learning.
- GPU on AMC? Or connect PClex to an external PC with a GPU?



Reconstructed distribution by Tomography



Summary

- Waveform recorded by oscilloscopes or digitizers is essential for monitoring the longitudinal property of the beam.
- A high-speed digitizer with a large memory is required for the J-PARC MR to record the waveform for the whole acceleration period.
- Teledyne SPD ADQ14 AMC with Vadatech VT816 chassis is chosen as a new digitizer platform.
- After fixing some trouble during the integration process, the new digitizer started operating in the J-PARC MR in November 2024.
- Integration with GPU is under consideration.